

State of California
Department of Fish and Wildlife

Memorandum

Date: October 14, 2016

To: Ms. Lynn Sadler
Deputy Director
Department of Parks and Recreation

From: Sandra Morey, Deputy Director
Ecosystem Conservation Division



Subject: **Risk Assessment for Coontail (*Ceratophyllum demersum*)**

In response to the August 22, 2014 letter from the Division of Boating and Waterways requesting risk assessments for five species of aquatic plants identified by the California Department of Parks and Recreation as potentially invasive, please find enclosed the California Department of Fish and Wildlife's (CDFW) risk assessment findings and determination regarding coontail (*Ceratophyllum demersum*). Per Harbors and Navigation Code (HNC) section 64.5, CDFW included in their assessment:

- Whether coontail may obstruct navigation and recreational uses of waterways;
- Whether coontail may cause environmental damage, including threats to the health and stability of fisheries, impairment to birds' access to waterways and nesting, roosting, and foraging areas, deterioration of water quality resulting from plant decay, and harm to native plants;
- Whether coontail may cause harm to the state's economy, infrastructure, or manmade facilities such as state water storage facilities and pumping operations, by increasing flood risk, threatening water supplies by blocking pumps, canals, and dams necessitating early control efforts; and
- Whether coontail causes or is likely to cause any other harm to California's environment, economy, or human health or safety.

To ensure thorough consideration of the species' ecological characteristics and the specified impacts and threats, CDFW employed the U.S. Aquatic Weed Risk Assessment tool. As specified in HNC sec. 64.5, CDFW consulted with the Department of Food and Agriculture, the Department of Water Resources (DWR), the State Water Resources Control Board, the Department of Pesticide Regulation, and the Office of Environmental Health Hazard Assessment, to develop the risk assessment findings and determination.

HNC sec. 64.5 states for purposes of this section, "invasive aquatic plant" means an aquatic plant or algae species, including its seeds, fragments, and other biological materials capable of propagating that species, whose proliferation or dominant colonization of an area causes or is likely to cause economic or environmental harm or harm to human health.

While invasive species are categorically defined as non-native to the ecosystem in question, the section-specific definition for invasive aquatic plant makes no reference to species origin, which allows for consideration of native species, such as coontail. As fully detailed within the enclosed risk assessment, CDFW concludes that coontail is a native species that, given its potential and realized impacts and the section-specific definition, meets the criteria for an "invasive aquatic plant" that causes or is likely to cause economic or environmental harm or harm to human health in California. Though coontail meets the criteria for "invasive aquatic plant," as defined in HNC sec. 64.5, CDFW and DWR caution that coontail is native throughout California's ecosystems, and as such, do not consider or categorize coontail as invasive outside of the HNC sec. 64.5(d) definition.

CDFW staff have completed a draft risk assessment for Carolina fanwort (*Cabomba caroliniana*), which is currently undergoing internal review. Per your July 13, 2016, request, CDFW staff is currently drafting the risk assessment of floating pennywort (*Hydrocotyle ranunculoides*).

If you have any questions regarding this risk assessment, or the others in process, please contact Ms. Martha Volkoff, Habitat Conservation Planning Branch, Invasive Species Program, at (916) 651-8658 or by email at Martha.Volkoff@wildlife.ca.gov.

Enclosure

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Aquatic Plant Risk Assessment

Coontail, *Ceratophyllum demersum* L.

September 29, 2016

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INTRODUCTION

The California Department of Parks and Recreation's Division of Boating and Waterways (DBW) is the lead agency of the State for the purpose of cooperating with other state, local, and federal agencies in identifying, detecting, controlling, and administering programs to manage, control, and when feasible, eradicate invasive aquatic plants in the Sacramento-San Joaquin Delta, its tributaries, and the Suisun Marsh. Harbors and Navigation Code (HNC) §64.5 defines an "invasive aquatic plant" as an aquatic plant or algae species, including its seeds, fragments, and other biological materials capable of propagating that species, whose proliferation or dominant colonization of an area causes or is likely to cause economic or environmental harm or harm to human health. Per HNC §64.5, for aquatic plant species that DBW believes may be invasive and desires to manage, control, or eradicate, DBW shall request that the California Department of Fish and Wildlife (CDFW) conduct a risk assessment to determine if the species causes or is likely to cause economic harm or environmental harm or harm to human health. The risk assessment shall be documented in a way that clearly describes the severity and types of impacts caused or likely to be caused by a plant species determined to be an invasive aquatic plant. Within 60 days after completing the risk assessment, CDFW shall report its findings to DBW.

DETERMINATION

Per DBW's August 26, 2014 request, CDFW evaluated whether coontail, *Ceratophyllum demersum*, should be considered an invasive aquatic plant in California. HNC §64.5 states for purposes of this section, "invasive aquatic plant" means an aquatic plant or algae species, including its seeds, fragments, and other biological materials capable of propagating that species, whose proliferation or dominant colonization of an area causes or is likely to cause economic or environmental harm or harm to human health. While invasive species are categorically defined as non-native to the ecosystem in question, the section-specific definition for invasive aquatic plant makes no reference to species origin, which allows for consideration of native species, such as coontail. To make the determination, CDFW selected a quantitative assessment tool that evaluated aspects of the species' ecology, reproductive potential, dispersal mechanisms, competitive ability, actual and potential impacts (including impacts to navigation and recreation, the environment, economy, and human health as specified in HNC §64.5), and resistance to management. Based on this evaluation, the findings contained herein,

and the definition provided in HNC §64.5(d), CDFW, in consultation and concurrence with California Department of Water Resources (DWR), State Water Resources Control Board (SWRCB), Department of Food and Agriculture (CDFA), Department of Pesticide Regulation (DPR), and Office of Environmental Health Hazard Assessment (OEHHA), determines coontail is a native species that, given its potential and realized impacts and the section-specific definition, meets the criteria for an “invasive aquatic plant” that causes or is likely to cause economic or environmental harm or harm to human health in California. Though coontail meets the criteria for “invasive aquatic plant,” as defined in HNC §64.5, CDFW and DWR caution that coontail is native throughout California’s ecosystems, and as such, do not consider or categorize coontail as invasive outside of the HNC §64.5(d) definition.

CURRENT DISTRIBUTION

Coontail is native to California and widespread up to 2500 m elevations (DiTomaso and Healy 2003; Calflora 2016). It occurs in 38 of California’s 58 counties and is documented in each of the following geographic provinces as classified by the State Wildlife Action Plan (CDFW 2015): Central Valley and Sierra Nevada, Cascades and Modoc Plateau, North Coast and Klamath, throughout the Bay-Delta and Central Coast, including the East, West, and South (San Francisco) Bay, South Coast, and Deserts (Calflora 2016).

Coontail is not currently regulated as a noxious weed in the U.S., but according to the Weed Science Society of America, coontail is reported as a most troublesome and/or most common weed in aquatic habitats and wetlands in Alabama, Georgia, and Puerto Rico (CISEH 2016). As of 2012, coontail was recognized as New Zealand’s worst submerged weed (Champion et al. 2012).

RISK ASSESSMENT

Coontail was assessed using the U.S. Aquatic Weed Risk Assessment (USAqWRA) tool, which was modified for the U.S. by Gordon et al. (2012) from the New Zealand Aquatic WRA model (Champion and Clayton 2001). The USAqWRA functions as the aquatic alternative to the Australian WRA, which is widely accepted and applied, but inaccurately classifies nearly all aquatic species as invasive, thus requiring modification for the accurate assessment of aquatic plants (Gordon and Gantz 2011). The USAqWRA has been tested for accuracy and validated under the environmental conditions of the U.S. and is the only assessment tool developed for the U.S. that maximizes accuracy for aquatic plants and incorporates all of the factors outlined in HNC §64.5.

The USAqWRA defines non-invaders as having no evidence of establishment outside of cultivation (in non-native ranges). Minor invaders are defined as species that have established in non-native ranges, but with no described ecological impacts. Major invaders are defined as having established in non-native ranges, and having documented, negative ecological impacts. Species are categorized using a scoring system of <31 (non-invaders), 31 – 39 (evaluate further), and >39 (major invaders). Gordon et al. (2012) determined that using the threshold score of 39 to distinguish major invaders from both minor and non-invaders maximized overall accuracy of the assessment tool at 91%.

CDFW conducted a thorough search of peer-reviewed journals and government publications to accurately complete the assessment. The resulting evaluation of coontail invasiveness (Appendix A) produced a score of 58, predicting coontail to be a “major invader” of the Sacramento-San Joaquin Delta. The findings using the USAqWRA model are summarized below, along with additional findings relevant to assessing potential impacts.

ECOLOGY

Coontail is a submerged, free-floating macrophyte that exhibits an annual to perennial growth pattern. Branched stems, with stiff, whirled, bottlebrush-like leaves, can reach over 6 m in length, though lengths of 10 m have been reported in New Zealand (R. Wells, NIWA, personal communication [ISSG 2006]; Champion and Hofstra 2013; Les 2016). In

California, coontail flowers from June through August; seeds and turions germinate in spring, though germination cues are not described in the literature (DiTomaso and Healy 2003; Calflora 2016). In cold-winter climates, plants sink to the bottom to overwinter, maintaining photosynthetic biomass but not actively growing. In warm-temperate to subtropical climates, plants maintain slow growth and reproduction of seeds and turions through the winter. Turions may remain on the parent plant through the winter, or separate following formation (Fukuhara et al. 1997; DiTomaso and Healy 2003; ISSG 2006).

Coontail commonly occurs in a variety of freshwater habitats, including ponds, lakes, wetlands, and irrigation canals (ISSG 2006). As a rootless, free-floating macrophyte, coontail is better suited for still as opposed to flowing or tidal waters. However, coontail rhizoids can anchor the plant in sandy to silty substrates, as well as to existing mats of vegetation such as *Egeria densa* in the Delta, enhancing its abilities to establish in flowing waters (Santos et al. 2011; ISSG 2006). Coontail is tolerant of low light and fluctuating water levels; it grows in depths of 0.5 – 15.5 m, though optimal depth range is 2.5 – 5 m (Wells et al. 1997; Clayton and Champion 2006; DiTomaso and Healy 2003). Coontail tolerates water temperatures ranging from ice cover to $\geq 35^{\circ}\text{C}$ ($\leq 32 - \geq 95^{\circ}\text{F}$), salinities up to 5 ppt, and pH levels ranging from 6 – 10 (Spencer and Wetzel 1993; CABI 2008; Hinojosa-Garro et al. 2008; Hyldgaard and Brix 2012; USDA-NRCS 2016). Coontail occurs in oligotrophic to eutrophic waters; however, it does best in high-nutrient waters (Wells et al. 1997; DiTomaso and Healy 2003).

REPRODUCTIVE POTENTIAL

Coontail reproduces sexually and vegetatively, through auto- and allo- stem fragmentation and production of turions (Fukuhara et al. 1997; DiTomaso and Healy 2003). In cold climates, few to no seeds are produced, while in warmer climates seeds can be abundant, though estimates of seed production are not quantified in the literature (Osborne and Polunin 1986; DiTomaso and Healy 2003). Coontail is monoecious, both cross- and self- compatible, and hydrophilous (CABI 2008). Though Guppy (1897) reported seed germination rates above 60% after a one-year dormancy period, Wyman and Francko (1986) achieved a maximum germination rate of 10% and suggests seeds are of minimal importance to coontail propagation. In New Zealand, where coontail is considered invasive, there is no evidence of seed production (Champion and Hofstra 2013).

Perennation and propagation of coontail is likely primarily through fragmentation and production of turions, specialized dormant propagules. In Japan, Fukuhara (et al. 1997) found nearly 90% of young coontail shoots had developed from turions. In Niigata, Japan, two to three hardiness zones cooler than in the Delta, turion development began as early as August and completed from the end of October on; $\leq 55\%$ of main shoots and $\leq 10\%$ of lateral shoots produce turions (35.7 turions/ 1 g dry plant biomass; Fukuhara et al. 1997). In Japan, autofragmentation was observed at the end of August, as plants began to form turions and prepare for dormancy (Fukuhara et al. 1997). Allofragmentation (mechanical damage) may occur year-round; coontail growth is minimally impacted by fragmentation, with shoot and fragment survival rates of 100%, new fragments producing flowers and additional viable fragments within weeks, indicating high colonization potential (Vari 2013).

DISPERSAL MECHANISMS

The literature suggests coontail dispersal is primarily by stem fragments and turions rather than seed production. Coontail seeds and turions sink to the bottom upon separation, minimizing distribution by water currents until young plants reach approximately 4" in length, at which point they detach from the substrate (DiTomaso et al. 2013). Mats and mature plants may use rhizoids to anchor to substrates or established vegetation, but are prone to dislodging and subsequent dispersal within the watershed (DiTomaso and Healy 2003). Stem fragments are easily transported to other watersheds via watercraft, recreational gear, and equipment (Johnstone et al. 1985; de Winton et al. 2009), while

waterfowl and other animals can transport fragments, turions, and seeds on their plumage, feet, or fur (DiTomaso and Healy 2003; CABI 2008).

Coontail introductions and dispersals have been attributed to the aquarium, pond plant, and aquarist trades, as well as linked to non-native fish introductions (CABI 2008; de Winton et al. 2009). In California, its native status has resulted in the promotion of coontail as an alternative to other [non-native] invasive submerged plant species by organizations including Cal-IPC (2007) and University of California's Master Gardener Program (Geisel et al. 2009). Coontail has been widely recognized for its bioaccumulation abilities in waste- and heavy-metal-contaminated waters (Rai et al. 1995; Keskinan et al. 2004), which suggests its use in bioremediation may be another pathway of introduction to new sites.

COMPETITIVE ABILITY

In its invasive range, coontail stems have been observed reaching lengths up to 10 m tall (R. Wells, NIWA, personal communication [ISSG 2006]). Forming dense canopies, coontail is able to shade out other submerged plant species, such as *Elodea canadensis*, particularly in depths > 2 m (Wells et al. 1997). However, its submersed growth habit and typical range of depth do not typically facilitate displacement of floating or emergent macrophytes. Coontail exudes allelopathic compounds that are most widely recognized for inhibiting phytoplankton, cyanobacteria, and algae, though Jones (1995) suggests coontail extracts and organic matter inhibited growth of *Hydrilla verticillata* and *Myriophyllum spicatum*.

Coontail has been strongly associated with *Egeria densa* in both the Delta and invaded waters in New Zealand (Wells et al. 1997; de Winton et al. 2009; Santos et al. 2011). The noted co-occurrence with *E. densa* indicates a high competitive ability and may suggest niche partitioning between the two species. In Kotukutuku Bay, New Zealand, coontail and *E. densa* have displaced nearly all other macrophytes beyond 2 m depth, with *E. densa* the dominant invader from 2 – 10 m and coontail forming a monospecific stand from 10 – 14.5 m (Wells et al. 1997).

REALIZED AND POTENTIAL IMPACTS

Given that coontail is native to much of North America and does not appear to have been widely recognized as a nuisance in the U.S., much of the impacts addressed in this section are impacts observed in its invaded range or potential impacts that are or may be realized in native ecosystems where coontail growth becomes excessive, commonly in high nutrient waters that drain agricultural lands (Goulder and Boatman 1971).

Obstruction of Navigation and Recreation

Where coontail growth is excessive, such as in slow-moving water, dead-end sloughs, and bays in the Delta (DBW, personal communication), the large sub-surface mats are able to hinder navigation and recreation similarly to other overabundant submerged aquatic vegetation, by tangling propellers and angling gear and interfering with or entangling swimmers (DiTomaso and Healy 2003; Champion et al. 2012).

Environmental Effects

Water quality – Increased coontail cover alters water quality by slowing water flows, decreasing turbidity (increased sedimentation rates), and, in eutrophic systems, reducing concentrations of total phosphorous, ammonium-N (NH_4^+ -N), and chlorophyll a (Dai et al. 2012). Water quality is further altered within coontail canopies, where temperature, dissolved oxygen, and pH levels are significantly higher than in surrounding habitats (Colon-Gaud et al. 2004), though dense growth and subsequent decomposition can lead to dissolved oxygen depletion, particularly in shallow waters. Reduced turbidity combined with coontail's allelopathic effects

upon phytoplankton, cyanobacteria, and algae may result in increased light penetration and stabilized dominance of aquatic macrophytes over phytoplankton (Scheffer et al. 1993; Gross 2003; Gross et al. 2003). Coontail is utilized in restoration and bioremediation efforts for its ability to remove wastes and contaminants from polluted waters. In situ decomposition of coontail, as opposed to harvesting, likely has further implications upon water quality as nutrients are released back into the water column.

Native plants – Under ideal conditions, particularly in high nutrient waters such as the Delta, coontail is able to establish monospecific or co-dominant (frequently with *E. densa*) stands by displacing or outcompeting other submerged plant species (Wells et al. 1997; Santos et al. 2011). Coontail is a native species in North America and its ability to outcompete and/or displace other native species has not been well-studied or documented to the extent of common [non-native] invasive plants.

Birds and waterfowl – As a submerged plant, coontail is not recognized for interfering with birds' access to nesting, roosting, or foraging habitats in the Delta. Many waterfowl species will consume the leaves, stems, and seeds of coontail, though it is recognized as only a minor food plant for waterfowl (USDA-NRCS 2016; MDNR 2016; WADOE 2016).

Health and stability of fisheries – As with other submerged aquatic vegetation, at intermediate densities coontail provides habitat and shelter for juvenile and prey fishes and may provide ambush cover for predatory fishes (Crowder and Cooper 1982). Also consistent with other submerged aquatic plant species, excessive growth of coontail, particularly in shallow waters, can ultimately result in depletion of dissolved oxygen levels and potential fish kills.

Economic, Infrastructure, or Man-made Facilities

Detached, floating coontail mats, particularly where growth is excessive, threaten to block or clog irrigation canals and pumps, dam trash racks, flow-metering devices, municipal intakes, and industrial and hydroelectric power plant intakes (DiTomaso and Healy 2003; Champion et al. 2012). In New Zealand and India, coontail is a dominant invader described as clogging hydroelectric facilities and reducing water storage capacities, increasing losses to evapotranspiration, and impacting drinking water supplies in reservoirs (Clayton and Champion 2006; Champion et al. 2012; Dhore et al. 2012). The Imperial Irrigation District (2010) identifies coontail as a troublesome aquatic weed, prevalent within California, which impacts drains and canals within their Vegetation Management Unit. In 2016, coontail and *Egeria* blocked the intakes and fish screens at Barker Slough Pumping Plant in the North Delta, causing forced shutdowns and loss of water delivery to municipalities (T. Veldhuizen, DWR, personal communication).

Human Health

Coontail has the potential to impact human health by increasing flood risks, facilitating mosquito reproduction, and entangling swimmers. Excessive coontail growth slows water flows, increasing water levels and the risks of flooding (DiTomaso and Healy 2003). Reduced water flows, paired with subsurface to surface mats of vegetation create ideal habitat for mosquito reproduction and larval development; chemical compounds found in coontail are oviposition attractants for mosquitoes of the genera *Aedes* and *Anopheles* (Bentley and Day 1989; Elias 1996; Torres-Estrada et al. 2005). Though not directly attributed to coontail as a species, excessive growth of submersed plant species is recognized for entangling swimmers and has been linked to drowning incidents in the U.S. (CAST 2014).

RESISTANCE TO MANAGEMENT

A variety of control methods are available for management of coontail, including chemical application, mechanical harvesting, dewatering, and bottom barriers or grass carp (DiTomaso et al. 2013). Mechanical harvesting may provide adequate control in some temperate areas; however, the increased production of fragments is likely to exacerbate the extent and degree of coontail infestations, particularly in lotic systems. Neither dewatering nor the introduction of grass carp are feasible methods of coontail control in the Delta ecosystem. Though coontail is a preferred plant by grass carp, their introduction is regulated in California and reserved for closed systems. Bottom barriers may reduce seedling and turion establishment, but since coontail is a rootless, free-floating plant, barriers are not considered a viable control method.

Coontail can be effectively controlled by herbicides, commonly by endothall and fluridone (Hofstra and Clayton 2001; DiTomaso et al. 2013). In Wisconsin, whole-lake fluridone treatments targeting Eurasian watermilfoil (*Myriophyllum spicatum*) significantly reduced the frequency of coontail occurrence for 6 years post-treatment (Wagner et al. 2007). In a eutrophic Minnesota lake dominated by *M. spicatum* and coontail, low-dose (6 ppb fluridone) whole-lake treatment reduced the frequency of coontail in the littoral zone for ≥ 2 years (Valley et al. 2006). Diquat may provide effective control of coontail in clear waters, but in turbid waters binds to clay and charged particles and becomes inactivated (Hofstra et al. 2001; DiTomaso et al. 2013).

The aforementioned active ingredients are currently allowed for use under the Statewide General National Pollutant Discharge Elimination System Permit for Residual Aquatic Pesticide Discharges to Waters of the United States from Algae and Aquatic Weed Control Applications, Water Quality Order 2013-0002-DWQ. If additional aquatic pesticide active ingredients approved by DPR are proposed to be used for coontail control other than 2,4-D, acrolein, calcium hypochlorite, copper, diquat, endothall, fluridone, glyphosate, imazamox, imazapyr, penoxsulam, sodium carbonate peroxyhydrate, sodium hypochlorite and triclopyr-based algaecides and aquatic herbicides, and adjuvants containing ingredients represented by the surrogate nonylphenol, the SWRCB can amend the above referenced permit to add the DPR-approved aquatic pesticide(s). The amendment process typically requires around four months to process and is initiated by written request to the SWRCB-Division of Water Quality (R. Norman, SWRCB, personal communication). However, per the current United States Fish and Wildlife Service Biological Opinion, and National Marine Fisheries Service concurrence, only fluridone, penoxsulam, imazamox, and to a limited (restricted) extent, diquat may be utilized within DBW's aquatic weed control program for submerged aquatic vegetation; endothall is not currently permissible within DBW's aquatic weed programs.

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APPENDIX A: Risk Assessment of Coontail, *Ceratophyllum demersum*

Species: Coontail; <i>Ceratophyllum demersum</i>					
	Question - USAqWRA	Score and guidance – USAqWRA	Score	Justification	Reference
1.1	Temperature tolerance	(0-3) Score 3 if maintains photosynthetic tissue and summer growth form throughout winter, 2 if dies back to tuber/bulb/rhizome (or similar structure) during winter, 1 if adult plants completely die but viable seeds remain. Use a climate matching tool if direct evidence is not available. Default = 1 for annual species.	3	Tolerates ice cover; sinks to bottom to overwinter in temperate regions, maintaining photosynthetic biomass through winter.	Spencer and Wetzel 1993; DiTomaso and Healy 2003
1.2	Range of habitat	(1-3) Score 3 if able to grow from water to dry land, 2 if water to wetland, or from shallow to deep (>5 m) water, 1 narrow range. Default = 1 if no information is available; 2 for free-floating plants, unless more information is available.	2	Free-floating and grows from shallow water to deep, 0.5 m to 15.5 m.	Wells et al. 1997; DiTomaso and Healy 2003; Clayton and Champion 2006
1.3	Water/ substrate type tolerance	(1-2) Score 2 if tolerant of sandy to muddy (or peaty) substrate, or oligotrophic to eutrophic waters, 1 if restricted by either. Default = 1 if no information is available.	2	Tolerates sandy to silty substrates and oligotrophic to eutrophic waters.	Wells et al. 1997; DiTomaso and Healy 2003; Vari 2013
1.4	Water clarity tolerance	(0-1) Score 1 if unaffected by water clarity (i.e. floating or emergent, or submergents tolerant of very low light levels, such as <i>Myriophyllum spicatum</i> and <i>Hydrilla verticillata</i>), 0 if affected by water clarity.	1	Tolerates low light levels.	Spencer and Wetzel 1993; Wells et al. 1997; DiTomaso and Healy 2003
1.5	Salinity tolerance	(0-1) Score 1 if species can tolerate saline conditions, 0 if not. Habitat information can be used to determine a score of 0 if species is only found to occur in freshwater habitats.	0	Does not tolerate salinities above 5 ppt; leaf damage and necrosis occur.	Hinojosa-Garro et al. 2008
1.6	pH tolerance	(0-1) Score 1 if tolerant of both acidic and basic pH or no information is available, 0 if restricted to neutral, basic, or acidic pH.	1	Tolerates pH levels ranging from 6 – 10.	CABI 2008; Hinojosa-Garro et al. 2008
1.7	Water level fluctuation - Tolerates periodic flooding/drying	(0-3) Score 3 for species which have evidence of tolerating periodic flooding/drying with a specified time period longer than 1 month (e.g., "months"; "X months", "winter flooding"), 2 for evidence of tolerance of flooding/drying over a period of days/a couple of weeks, 1 for species that die back during periods of flooding/drying, and 0 for species that do not tolerate flooding/drying. Do not score if there is no information available.	1	Tolerant of fluctuating water levels, but abundance/frequency is reduced by winter drawdown and subsequent drying. Fragments are highly susceptible to active desiccation, but no information is available on viability	Hestand and Carter 1974; Clayton and Champion 2006; Barnes et al. 2013

				following passive desiccation.	
Species: Coontail; <i>Ceratophyllum demersum</i>					
	Question - USAqWRA	Score and guidance – USAqWRA	Score	Justification	Reference
2.1	Lotic - Rivers, streams, drains, or other flowing waters, including their margins	(0-3) Score 3 if major weed (reaches high density and dominates plant community), 2 if minor weed (common, but rarely or never dominant), 1 if present but not weedy, 0 if absent.	2	Better suited for non- or slow-flowing waters. Common and weedy, but typically co-dominant at most and due to depth partitioning.	Wells et al. 1997; DiTomaso and Healy 2003; Santos et al. 2011
2.2	Lentic - Ponds, lakes and other standing waters, including their margins	(0-3) Score 3 if major weed (reaches high density and dominates plant community), 2 if minor weed (common, but rarely or never dominant), 1 if present but not weedy, 0 if absent.	2	In its invasive range (NZ), coontail is dominant to co-dominant species. In the U.S., it is a common species, but rarely the dominant species.	Champion et al. 2012
2.3	Swamp, marsh, bog, or other wet areas not covered by 2.1 or 2.2	(0-3) Score 3 if major weed (reaches high density and dominates plant community), 2 if minor weed, 1 if present but not weedy, 0 if absent.	1	Numerous studies and reports document the presence of coontail in U.S. wetlands, but do not indicate notable negative impacts.	Eggers and Reed 1997; Poirrier et al. 2010
2.4	Establishment - into existing vegetation	(-5, -3, 0) Score 0 if able to invade unmodified vegetation, -3 if the species can only colonize certain types of vegetation (e.g., turf-forming shoreline vegetation), -5 if there is no evidence that the species can move into intact vegetation. Default = 0 if there is evidence of establishment, but no specific information about level of invasion into existing vegetation and/or type of vegetation being invaded. Default = -3 for species that have not naturalized outside of their native range.	0	As a rootless species, coontail commonly relies on established macrophytes (e.g. <i>Egeria densa</i> , <i>Myriophyllum spicatum</i>) to serve as anchors facilitating its establishment.	Howard-Williams et al. 1996; Santos et al. 2011

2.5	Establishment - into disturbed vegetation	(0, 1, 5) Score 5 if able to aggressively colonize following vegetation clearance, newly constructed waterbodies or nutrient enrichment, 1 if the species grows in disturbed areas, but there is no other information, 0 if there is no evidence of establishment in disturbed areas. Information from either the native or introduced range may be used to answer this question. Default = 1 for no information.	1	Coontail fragments exhibit high regeneration and colonization potentials in both low and high frequency/intensity disturbed sites. Though, no evidence suggests aggressive colonization.	Barrat-Segreatin et al. 1999
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Species: Coontail; <i>Ceratophyllum demersum</i>					
	Question - USAqWRA	Score and guidance – USAqWRA	Score	Justification	Reference
3.1	Competition - between growth form	(0, 1, 2) Score 2 if species forms dense stands that are documented to displace other growth forms (submerged, floating, emergent), 1 if some suppression, 0 if no displacement. Default = 0 if species has been in the trade globally for >30 years and there is no information about the species displacing other growth forms.	0	Coontail is not recognized for displacing other growth forms.	
4.1	Dispersal outside catchment by natural agents (e.g. birds, wind)	(0, 1, 3, 5) Score 5 if species (including seeds, rhizomes, fragments etc.) well adapted, and likely to be frequently dispersed, by natural agents, 3 if transport by natural agents is possible but uncommon, 1 if propagule could be spread in bird crop, 0 if no, or extremely low, likelihood of dispersal by natural agents (e.g., <i>Hydrilla</i> is scored 1 because its turions can survive passage through duck guts, an agent of dispersal, but this is believed to happen rarely).	5	Fragments, seeds, and turions may be vectored by waterfowl and other aquatic animals. Detached, floating mats may be further dispersed by winds.	DiTomaso and Healy 2003; CABI 2008
4.2	Dispersal outside catchment by accidental human activity	(1, 2, 3) Score 3 if major pathway, seeds/fragments adapted for easy transportation (e.g., via boat/trailer, fishing gear), 2 if the species is a floating plant or a macrophyte, but no explicit mention of high spread in the literature, 1 not mentioned, not likely to be spread by human activity based on growth form and life history. Default = 1 if no information is available.	3	Fragments, seeds, and turions are easily transported by watercraft, gear, and equipment.	Johnstone et al. 1985; de Winton et al. 2009
4.3	Dispersal outside catchment by deliberate introduction	(0-1) Score 1 if species is desirable to humans (e.g., or used for medicinal, food, ornamental, restoration, etc. purposes in the U.S. or elsewhere). If species is not used or no information exists, score should be 0.	1	For plantings in California, coontail is currently promoted as a desirable, native alternative to [non-native] invasive submerged plant species. Recognized for its medicinal value in Turkey.	Cal-IPC 2007; Geisel et al. 2009; Dogan et al. 2015
4.4	Effective spread within waterbody/ catchment	(0-1) Score 1 for extensive spread within a waterbody or among waterbodies, 0 for no spread. Occurrence along streams or riverbanks or in rivers can be used as evidence, as well as evidence of water dispersal. Do not answer if no information is available.	1	Detached, floating mats easily disperse within a catchment. Extensive spread is also possible via production of highly viable fragments.	DiTomaso and Healy 2003

Species: Coontail; *Ceratophyllum demersum*

	Question - USAqWRA	Score and guidance – USAqWRA	Score	Justification	Reference
5.1	Generation time (time between germination of an individual and the production of living offspring, not seeds or other dormant structures)	(1, 2, 3) Score 3 if rapid (reproduction in first year and >1 generation/year), 2 if annual or produces one generation every year including the first year, 1 if not reproductively mature in the first year. Default = 1 if no information is available.	3	Fragmentation does not inhibit growth or continuation of the life cycle (developing shoots, flowering). New fragments exhibit rapid growth compared to <i>E. densa</i> and <i>M. spicatum</i> , 100 % survivorship, and produced flowers and additional viable fragments within weeks.	Vari 2013
6.1	Seeding ability - Quantity	(0-3) Score 3 if >1000 seeds/plant/year, 2 100-1000, 1 <100 and/or evidence that seed are produced (in native or introduced range), 0 if seed not produced.	1	In cold climates, few to no seeds produced. In warm climates, seed production can be abundant. Seed production is greater in stable waters (9 vs. 1.5 cc/m ²), but no estimate of quantity per plant was available. Seed production is a negligible method of reproduction.	Low and Bellrose 1944; Osborne and Polunin 1986
6.2	Seeding ability - Viability/persistence	(0-2) Score 2 if highly viable for >3 years, 1 low viability or evidence of seed production with no information on viability, 0 no viable seeds.	1	Viable seeds are produced within the native range, but no information is available regarding longevity of viability.	Guppy 1897; Wyman and Francko 1986
7.1	Vegetative reproduction	(0, 1, 3, 5) Score 5 for naturally fragmenting from rhizomes, stolons, or other vegetative growth into tissue capable of producing new colonies (e.g., <i>Egeria densa</i>), 3 if produces rhizomes/stolons, but there is no other information about the formation of new colonies elsewhere, 1 for clump-forming by vegetative spread, 0 for no vegetative spread.	5	Produces turions and fragments, both allo- and auto-.	Fukuhara et al. 1997; DiTomaso and Healy 2003
8.1	Physical - Water use, recreation	(0-2) Score 2 for major nuisance, 1 for minor nuisance. Default = 0 if the species has not naturalized outside of its native range.	1	Is recognized as a major nuisance in New Zealand lakes, but in California currently appears to be a minor nuisance	Clayton and Champion 2006; Champion et al. 2012

				relative to more dominant species.	
Species: Coontail; <i>Ceratophyllum demersum</i>					
	Question - USAqWRA	Score and guidance – USAqWRA	Score	Justification	Reference
8.2	Physical - Access	(0-2) Score 2 for major nuisance, 1 for minor nuisance. Default = 0 if the species has not naturalized outside of its native range.	1	Poses a nuisance in the Delta, impeding access to waterways by tangling boat props, but is not widely recognized in the U.S. for restricting access.	DBW, personal communication
8.3	Physical - Water flow, power generation	(0-2) Score 2 for major nuisance, 1 for minor nuisance. Default = 0 if the species has not naturalized outside of its native range.	2	Coontail poses a major threat to water flows, hydroelectric power generation, dam trash racks, and municipal intakes. Impacts State Water Project pumping plants and fish screens.	DiTomaso and Healy 2003; Clayton and Champion 2006
8.4	Physical - Irrigation, flood control	(0-2) Score 2 for major nuisance, 1 for minor nuisance. Default = 0 if the species has not naturalized outside of its native range.	2	Coontail poses a major threat to irrigation canals and pumps and may increase flood risks. Impacts State Water Project pumping plants and fish screens.	DiTomaso and Healy 2003; Imperial Irrigation District 2010
8.5	Aesthetic - Visual, olfactory	(0-2) Score 2 for both visual and odor problems, 1 either, 0 neither or no mention of these impacts. Surface matting of macrophytes scores 1 for visual impact.	1	Surface and subsurface matting constitute a visual impact.	
9.1	Reduces biodiversity	(0, 1, 3, 5) Score 5 for extensive monospecific stands, 3 for species that become dominant, 1 for small monospecific stands, and 0 if species does not become dominant over other species.	1	Recognized for displacing native species in New Zealand. In the U.S., is typically only co-dominant at most, and may form monospecific stands at greater depths.	Wells et al. 1997; Santos et al. 2011

9.2	Reduces water quality	(0, 1, 3) Score 3 if evidence that this species causes deoxygenation (e.g., through extensive growth in shallow water) or other water quality loss (e.g., loss of water clarity because of high decomposition rates continuously during the growing season), 1 if deoxygenation or other water quality loss is likely based on seasonal growth cycles (e.g., macrophyte that gets to high density and dies off at end of summer), 0 otherwise.	3	Extensive growth and decomposition result in deoxygenation. Coontail alters concentrations of phosphorous, ammonium-N, chlorophyll a. Releases allelopathic compounds affecting phytoplankton, cyanobacteria, and algae.	Gross 2003; Gross et al. 2003; Dia et al. 2012
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Species: Coontail; <i>Ceratophyllum demersum</i>					
	Question - USAqWRA	Score and guidance – USAqWRA	Score	Justification	Reference
9.3	Negatively affect physical processes	(0, 2) Score 2 if species alters hydrology (e.g., increases the chance of flooding) or substrate stability (e.g., increases amount of sediment erosion or deposition), or other physical processes, 0 if the species has no history of modifying physical processes.	2	Slows water flows, increasing sedimentation rates. Indirectly increases light penetration by impacting water clarity.	DiTomaso and Healy 2003; Scheffer et al. 1993
10.1	Human health impairment (e.g. drowning, poisonous, mosquito habitat)	(0-2) Score 1 for one effect, 2 for 2 or more effects.	2	Increases flood risk, creates ideal mosquito habitat and is an oviposition attractant for vector species. May pose a risk of entanglement to swimmers.	Bentley and Day 1989; Elias 1996; DiTomaso and Healy 2003; Torres-Estrada et al. 2005; CAST 2014
10.2	Weed of agriculture, including crops, livestock and aquaculture	(0-1) Score 1 if a problem agricultural weed, 0 if no evidence that it is an agricultural weed, or if evidence states that species is in agricultural areas but not problematic.	0	Not recognized as an agricultural weed.	
11.1	Management - Ease of management implementation	(0-2) Score 2 if accessibility to weed is difficult, e.g. dense tall impenetrable growths or growing in habitats that are difficult to access by roads or waterways (e.g., swamps). For species that have naturalized outside of their native range, default = 0-2 based upon evidence about habitat and/or growth form if there is no direct evidence from the literature.	0	Accessibility is not an impediment to the treatment of coontail.	
11.2	Management - Recognition of management problem	(0-1) Score 1 if difficult to assess weed, (e.g., submerged; looks like another species). For species that have naturalized outside of their native range, default to a score between 0-1 based upon growth form evidence if there is no direct evidence from the literature.	1	Coontail may be difficult to assess given its submersed growth habit and its similar appearance to <i>Cabomba caroliniana</i> , <i>M. spicatum</i> , <i>M. sibiricum</i> , <i>Limnophila X ludoviciana</i> , and <i>Ranunculus aquatilis</i> .	DiTomaso and Healy 2003
11.3	Management - Scope of control methods	(0, 1, 2) Score 2 if no control method, 1 if only one control option. If species has naturalized outside of its native range, and there is no direct evidence for either 11.1 or 11.2, do not answer if there is no information. If there is direct evidence for 11.1 and/or 11.2, default to 0 if there is no information for this question.	0	A broad suite of control methods are available for treatment of coontail.	DiTomaso et al. 2013

Species: Coontail; *Ceratophyllum demersum*

	Question - USAqWRA	Score and guidance – USAqWRA	Score	Justification	Reference
11.4	Management - Control method suitability	(0-1) Score 1 if control method not always acceptable (e.g., grass carp, unregistered herbicide). If species has naturalized outside of its native range, and there is no direct evidence for either 11.1 or 11.2, do not answer if there is no information. If there is direct evidence for 11.1 and/or 11.2, default to 0 if there is no information for this question.	1	Fluridone is generally acceptable, but is not a viable option in front of pumping plants and intakes due to necessary contact time. Via the current Biological Opinion, endothall is not permissible and use of diquat is regulated in the Delta. Grass carp are not a viable (permissible) control option in California's open-water systems.	Department of Water Resources, personal communication; California Fish and Game Code § 6440 et seq.
11.5	Management - Effectiveness of control	(0, 1, 2) Score 2 if ineffective, 1 if partial control. If species has naturalized outside of its native range, and there is no direct evidence for either 11.1 or 11.2, do not answer if there is no information. If there is direct evidence for 11.1 and/or 11.2, default to 0 if there is no information for this question.	0	Chemical control is effective where necessary contact time is achievable and water use restrictions are not a factor. Fluridone may control coontail for a minimum of 2 – 6 years post-treatment.	Valley et al. 2006; Wagner et al. 2007
11.6	Management - Duration of control	(0, 1, 2) Score 2 if no control, 1 if control for 3+ months. If species has naturalized outside of its native range, and there is no direct evidence for either 11.1 or 11.2, do not answer if there is no information. If there is direct evidence for 11.1 and/or 11.2, default to 0 if there is no information for this question.	1	Chemical control is effective. Fluridone may control coontail for a minimum of 2 – 6 years post-treatment.	Valley et al. 2006; Wagner et al. 2007
12.1	Problem in other countries	(0, 1, 3, 4, 5) Score 5 if species has been reported to be a widespread problem (i.e., a harmful weed in many other countries), 4 if species has been reported to be a harmful weed in 5 or fewer countries, 3 if species has been reported to be a widespread adventive (but not a harmful weed) in many other countries, 1 if species has been reported to be adventive in 5 or fewer countries, 0 if not adventive elsewhere.	4	Reported as a harmful weed in New Zealand, Puerto Rico, China, Japan, and India, as well as most common/troublesome in Alabama and Georgia.	Cao and Wang 2012; Champion et al. 2012; CISEH 2016
USAqWRA Score			58		

